corDECT Training Manual

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1. Introduction

A few years ago hardly anyone would have thought of a local loop as anything more than the physical wires connecting the telephone subscribers' phone or public branch exchange (PBX) to the telephone company's central office switch. That is beginning to change as wireless local loops (WLL) find their way into densely populated areas as well as secluded and remote areas. Most telecommunication majors in the world have identified WLL as a significant emerging market. It does not require a great extent of market research to find the reasons. There are 5.5 billion people in the world and only a small fraction of them -say, 10% have telephones and most of these are in the larger urban homes and businesses of the USA, Canada, Western Europe, Japan and Australia. The market for WLL systems in the developed world who already have a well developed copper / fiber optic cable infrastructure is not likely to be as big as that in third world countries. This is because countries with an underdeveloped telecommunication infrastructure have realized that a country's economic development and success in today's global market is significantly dependent on the quality of telecommunications. As a result these countries would want to leap frog into state of the state of the art technologies like Wireless Local Loop to cost effectively and efficiently develop their telecommunication infrastructure in the least possible time.

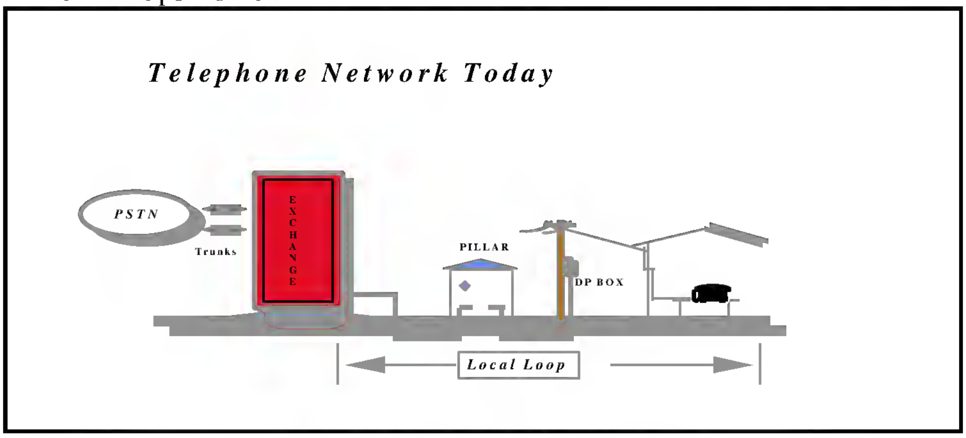


Figure 1 - A Telephone Network Today

1.1 Important Attributes of a WLL system

A WLL technology meant for urban areas must, first and foremost, be capable of catering to upwards of a million subscribes densely populated metropolitan area. This can be achieved, given an operating bandwidth, howsoever generous, only by spatial frequency reuse as is done in mobile cellular systems. The capacity of a cellular system for a given bandwidth is determined only to some extent by the modulation format and other related parameters and primarily by the reuse factor, or equivalently, cell size. As one makes the cells smaller, the transmit power levels are reduced, and the same frequency can be reused more often, leading to higher capacity. A lower transmit power level incidentally also serves to extend battery life in the hand sets.

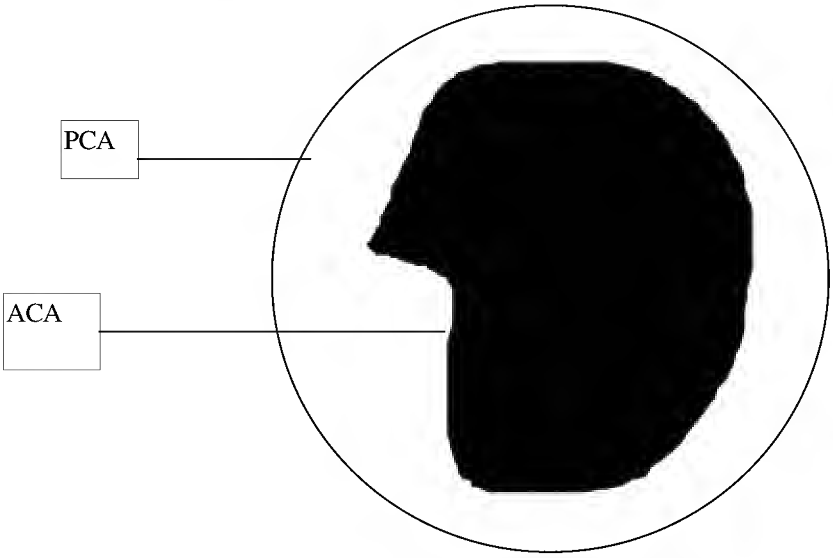
1.2 Capacity

While a micro-cellular architecture is the only route to high capacity, there are problems associated with it. At low transmit-power levels, the cell shape (the area reached by the transmitted signal) is very unpredictable as it depends on the local propagation profile, obstructions, etc. Irregular cell shapes and sizes render any attempt at cell planning and frequency planning futile.

1.3 Cell Planning

Cell planning can be avoided in the following manner. Associated with each cell is a potential coverage area (PCA) under free-space propagation conditions, and an actual coverage area (ACA) determined by the local propagation conditions(Figure 1) . The ACA need not even be contiguous, but will be contained in the PCA. The ACA is the irregularly - shaped cell that is unpredictable. The solution to covering the entire area is to overlap PCAs generously so that the probability of any location not falling in at least one ACA is very small. Most locations will fall in more than one ACA.

Figure 2 - Potential coverage area(PCA) under free-space propagation conditions and actual coverage



area (ACA) of a cell

1.4 Frequency Planning And Reuse

Frequency reuse can be planned when the cell boundaries and sizes are at least approximately predictable. In mobile cellular systems, frequencies are allocated in a planned manner, and a subscriber crossing over from one cell to another to another hands over the call from one frequency and goes to another. The hand over is administered by the Base station. or cell site associated with each cell. In a micro-cellular system, frequency planning is ruled out, and hand-over must be decided by the handset at the subscriber end based on measured interference levels at that point in space and time. To achieve a very high probability of successful hand over, each handset must have the potential choice of all available frequencies earmarked for the entire system without apportioning them among the cells. In an FDMA system this means that a handset must be capable of switching over during a call to any of the few hundreds of FDMA channels. In a FDMA system, the handset must be capable of transmitting on any time-slot on any of the available frequencies. Thus, the frequency can change from slot to slot. This type of TDMA is referred to as Multi-Carrier TDMA (MC-TDMA) and is a cross between conventional FDMA and TDMA.

1.5 Inter cell Hand over

In a micro-cellular system with handset-arbitrated hand over, the interference profile changes with time even at a fixed location because of other hand set in the vicinity taking independent decisions. Thus, even a fixed handset may switch over during a call from one channel to anther (intra-cell hand over),and/or from one base station to another in regions of overlapping ACAs(inter-cell hand over).

1.6 Migration of inter- cell capacity

Another important attribute of a WLL system is its ability to migrate capacity to areas where call density is high at certain times. A micro-cellular system with overlapping ACAs achieves this goal since handsets can typically access more than one base station from a large fraction of the covered area. During intervals when call density is high, a handset can probably access a second base station even if the best one from the point of view of link quality is fully busy serving other handset.

1.7 Redundancy

A final advantage accruing from having a large fraction of the area falling in multiple ACAs is that even if a base-station were to malfunction, handsets / wallsets could continue to operate via other base-stations whose ACAs overlap with the ACA of the malfunctioning base-station.

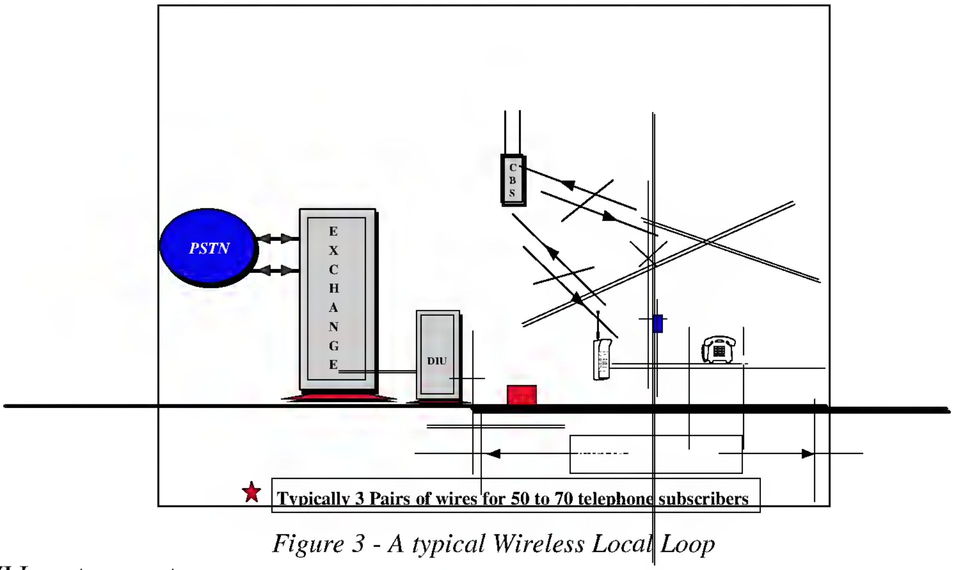


Figure 3 - A typical Wireless Local Loop

Thus, a WLL system must :

a) Be micro-cellular to achieve very high capacity and low transmit power levels.
b) Have overlapping cells to overcome cell-size unpredictability, to reduce the blocking probability by capacity migration, and to provide a measure of fault tolerance.
c) Have self-organizing handset-arbitrated hand-over to obviate the need for frequency planning
d) Interface easily with the major switch-types in the telecommunication networks
e) The quality and range of services provided over the wired loop should be maintained at atleast the same level and should be also to support services planned for the future.

What is a desirable Wireless Local Loop ?

- **Toll Quality voice (64 kbps PCM / 32 kbps ADPCM expandable to ISDN**
- **High Traffic handling capacity (0.05 E to 0.15 E per subscriber)**
- **Large telephone density (million subscribers in a city) with limited frequency spectrum**
- **Low Cost**
- **Low Power**

Figure 4 - Desirable Attributes of a Local Loop

2. Overview of Wireless Local Loop and Cellular Technologies

The concept of a WLL is not new. In some sense, mobile cellular systems, which have been around for more than a decade provide a WLL from a moving vehicle. In the case of a mobile subscriber, there is no other option but to use a WLL. A mobile cellular phone could also be used as a fixed or portable phone. Thus any existing mobile cellular system can be deployed to provide WLL to home, office, and vehicles. However, systems designed for mobile purposes have limitations when used as WLL for homes and office.

2.1 AMPS

This is a good example of a first-generation mobile cellular system. It is widely deployed in North America and a few other countries. AMPS operates in the 900 MHz band. It is an analog system using FM for the radio link between handset and base stations from where the voice signal enters the telephone network. The voice quality on the wireless link is not toll-quality. One implication of this is that the AMPS system does not guarantee every service normally possible from a wired telephone, for example,, data communication using modems, fax, etc. Digital services such as ISDN are also ruled out.

Prior to AMPS, mobile telephony was provided using radio channels allocated permanently to subscribers. Given the limited bandwidth availability, the number of subscribers was limited. AMPS was among the first to employ the cellular concept. In this approach, the coverage area is divided in to cells and a certain number of radio channels are allocated to each cell. As a subscriber moves for one cell to another, his call is handed over from one channel to another automatically by the system.

A key feature of the cellular approach is that frequencies can be reused in geographically dispersed cells. For example , AMPS has around 650 channels and reuses all the channels every 12 cells. The radius of an AMPS cell can vary from 2-15 km depending on the subscriber density expected in different geographical areas. The power transmitted from the handset is 1 W.

The Total Access Communications system (TACS) deployed in Europe is similar to AMPS.

2.2 Pan-European Cellular System (GSM)

A digital mobile cellular system has been standardized as a second generation cellular system and deployed all over Europe, and is now being adopted in many other countries like India and China. Like AMPS, it also operates in the 900 MHz band, though some bandwidth in the 1800 MHz band has also been allocated. Unlike AMPS, the system is digital, and the voice signal is digitized from the handset itself. In order to conserve bandwidth, the bit rate has been kept low at around 16 Kb/s. At this bit rate, it is not possible to provide toll-quality despite digitization - leading to the same limitations as mentioned above for the AMPS system.

GSM employs Time Division Multiple Access (TDMA) in contrast to AMPS which employs the conventional Frequency Division Multiple Access(FDMA). GSM also employs sophisticated techniques like power control from the handset or base station to the level needed depending upon the handset - base station separation at a particular time. This conserves battery charge and improves the frequency reuse efficiency. Cell sizes in GSM are of the same order as in AMPS, though somewhat smaller cells are also permitted.

2.3 Digital AMPS

In order to digitize the mobile phone system for improved quality and to get higher call-carrying capacity, a digital overlay on the AMPS system has been deployed. Here, an RF channel carrying one FM voice link in analog AMPS, now carries a three-channel digital TDMA signal, handling three calls. The system, like GSM, has all the advantages of a digital cellular system, while co-existing with installed analog AMPS systems. Dual-use hand set can operate both in areas with analog AMPS and digital AMPS. Digital AMPS also does not provide toll-quality voice links. The system is also referred to as North American Digital Cellular System or IS-54.

2.4 CDMA Cellular System

A new-generation digital mobile cellular system is emerging that employs spread spectrum modulation and code division multiple access(CDMA) that goes hand-in-hand with it. Similar to the other cellular systems, this system also does not provide toll-quality. CDMA systems require very accurate power control for proper operation. System performance is very sensitive to the accuracy of power control and until widely deployed and proven in the field the call-carrying capacity of CDMA systems will be questioned. CDMA systems have an important advantage that they do not need frequency planning. In all the other systems, RF channels have to be allocated to different cells depending on the expected subscriber density in that cell. As the density changes, cells have to be divided, extra channels allocated and so on; proper planned allocation of the available bandwidth is a non-trivial task.

2.5 Digital Enhanced Cordless Telecommunications (DECT)

All the cellular systems described till now have designed for the mobile WLL application, and are therefore optimized for it. They have been designed for certain typical levels of call traffic density (in Erlangs/sq. Km) consistent with expected call traffic and call hold-times from vehicles. Given that background noise in a mobile environment is anyway present, a lower voice quality level is acceptable in exchange for bandwidth efficiency. Full-fledged data services are not expected from vehicles, though an overlay data service called Cellular Digital Packet Data (CDPD) is now being implemented due to customer demand.

None of the mobile cellular systems is well-suited for use as a WLL for homes and offices. The call-carrying capacity of these systems is inadequate for the traffic levels generated by offices. The signal quality, being less than toll-quality, does not permit all the capabilities of a normal wired phone. Further, an upgrade to ISDN services is not possible. Since the cell sizes are large by design transmit power levels are high (~1W). This is not a problem in a powered vehicle but is a limitation for a portable phone. Finally, except CDMA, the mobile cellular systems cannot migrate capacity dynamically to geographical areas that need more capacity at a given time, due to the inherent limitation of fixed channel assignment to cells.

The DECT standard recently proposed by the European Telecommunication Standards Institute(ETSI) overcomes all these problems mentioned above, and is ideally suited for the WLL application. It can also be used for wireless PABXs, telepoint systems and wireless LANs. It is a third generation cellular system and is a precursor to the Personal Communication Network (PCN). A similar system called Personal Handy Phone (PHP) has been adopted in Japan.

Prior to DECT, a much simpler system called CT2, with some similarities to DECT was proposed and implemented. CT2 permits only outgoing calls from the handset, and is thus suitable only for use as a pay-phone. However, it is digitized from the handset onwards and does provide toll quality with a low transmit power of 10 mw. A recent addition to CT2, called CT+, integrates a pager with a CT2 handset. This allows the phone number of the calling subscriber of an incoming call to be displayed on the hand set, permitting the user to call back. In addition, CT2 and CT2+ employ Fixed Channel Allocation(FCA) and have very limited call-carrying capacity.

3. DECT Standards for WLL

DECT is an MC-TDMA self-organizing micro-cellular standard that has all the attributes of a WLL listed in the previous section, and more. Further, a DECT-GSM interface is being defined so that the same handset can work from the home, car and office. For countries like India which have decided in favor of GSM for cellular telephony, DECT is a very attractive standard to look into for the wireless local loop applications. A number of major international telecommunication companies have already announced DECT components and products.

3.1 Features of DECT

Listed below are several important features of DECT that make it a good choice for the wireless local loop.

a) **Frequency band -** 1880-1900 MHz - a new frequency band not clashing with the allocation for mobile cellular communications. A second frequency band is also being considered for enhancement.

b) **Mode of Multiple Access :** Multi-Carrier Time Division Multiple Access a modification of conventional TDMA which is as easily implemented but which gives greatly increased capacity.

c) **Voice Coding :** 32 Kb/s ADPCM half the bit-rate of PCM without any disadvantages. Provides toll quality services and can handle voice-band data and fax signals up to 9600 bits per second.

d) **Number of Frequency Bands :** 10 bands, each of 1.728 MHz bandwidth with twelve time-slots and 10 carrier frequencies, a total of 120 channels are available for dynamic selection.

e) **Number of simultaneous calls:** 12 per base station the system is Time Division Duplex (TDD), with twenty-four 32 Kb/s voice slots per frame. Along with signaling and other overhead, the total bit-rate is 1.152 Mb/s. Half- and Double-Slot Capability. It is possible to allot 64 Kb/s to a handset using a double slot. The number of voice channels can be doubled to 240 in future by using only one pair of half-slots per call and 16 Kb/s voice coding.

f) **Size of Cell and Transmit Power:** The “radius” of a cell is expected to be about 150 m under typical urban conditions, though the cell will rarely be circular and the average power is only 10mW (One tenth the power of a home cordless telephone.) .This low power level means that the phone can operate for long hours without re- charging the batteries. This is very important since the wireless phone will not be powered by the exchange, unlike a conventional phone.

g) **Subscriber Density:** DECT achieves very high, and non uniform, phone densities by employing a self-organizing handset-arbitrated dynamic channel selection scheme. Base stations can be installed in an uncoordinated fashion as subscriber density increases. DECT has been designed to handle subscribers densities as high as 5000/sq. Km.

h) **Enhancements:** DECT enhancements in the future are:

- DECT ISDN
- DECT Data
- Wireless LANs at upto 1.152 MBPS
- General Access Profile (GAP)
- Cordless Terminal Mobility

3.2 How Does DECT Provide High Traffic Capacity?

While the small cells used in DECT is key to the high capacity it provides, we have seen that small overlapping cells cause some problems. The unpredictable offered traffic, the unpredictable radio propagation environment and the unknown interference from the adjacent systems present a difficult scenario. Well-defined cells and frequency planning are therefore ruled out. DECT solves the problem by uncoordinated system installations co-existing on a common frequency resource for all systems. The systems operate in a self-organizing way choosing time frequency channel that for the time being are best for the desired local connection avoiding splitting of the common frequency resource between different services of user providing additional capacity gain:

- Allowing for easily engineered and economic installation of closer and closer cells
- Dynamic inter-cell and intra-cell hand over which elegantly copes with changing conditions, without need for central control. The hand overs are quick and seamless (without any interruption).

The Dynamic Channel Selection (DCS) and hand over technique is probably the most important concept which allows small cells with low power transmission and thereby high traffic density. The dynamic channel selection algorithm used in DECT is robust and efficient and the physical channels between hand sets and their closest base stations are allocate in a decentralized way by the hand sets.

An important advantage is that different systems and system operators and different types of services can utilize the same set of available channels without prior distribution of channels to specific services or base stations. This is in contrast to systems such as AMPS and GSM which operate on the principle of Fixed Channel Allocation (FCA). These systems therefore need to be planned for a worst-case situation, while DECT takes the actual interference situation into account. A consequence of the DECT dynamic channel selection procedure is that there is no need to plan in detail how many channels are needed per base station.

The Key to seamless hand over is TDMA in combination with the decentralized dynamic channel selection, where the old link is maintained on one slot in the handset, while the new link is set up in parallel on another time slot (and possibly another frequency). When the new link is established, the base station (which may be a new one now) requests the system to switch seamlessly from the old to the new channel.

The hand over is controlled by the handset. While the handset communities on the original link, it scans the other channels and records free channels and identities of base stations whose signals are stronger that the current one. Hand over is made when another base station stronger than the current one is found. To increase the probability of finding a stronger base station, base stations employ antenna diversity to change the radiation pattern. The hand over is performed well before the link quality deteriorates. DECT does not depend at all on the old channel to quickly set up the new one. The inter-cell and intra-cell hand over increased the capacity and cuts call curtailment drastically. The high capacity of DECT is primarily due to DCS as opposed to FCA used in the first and second generation cellular systems. The main advantages of DCS are as follows:

a) DCS does not need shadowing margins, as it adjusts to the instant situation allowing sometimes shorter and sometimes longer reuse distances.
b) DCS has a dynamic reuse distance also because portable close to the base station will have shorter reuse distances.
c) DCS gives better trunking efficiency since any of the 120 channels can be used by any base station or handset.
d) When DCS is used in conjunction with microcells, the average strength of the wanted signal increases as the cells are made smaller, leading to higher carrier to interference ratio.

4. DECT in the Wireless Local Loop

The objective of DECT technology is to provide telephones to business and homes in urban areas within a relatively short time and with minimum expenditure. These telephones are to be added to the existing network, providing services which are at least as good as those provided by the wired local loop today and also capable of adding services like Narrow band ISDN which are now being added on the wired loop. At the same time this technology should require no new network planning or numbering scheme. Ideally the new technology should be added to the existing telecommunication network with existing switches. Changes in the hardware or the software of the switches would be a huge task and would almost rule out the acceptance of the new technology. Even the administrative software of the switches should be changed to the minimum extent, if at all.

4.1 The Remote Line Switching Unit

The most straight-forward way to connect the DECT WLL to the existing network is to configure the it as a Remote Line Unit (RLU) or Remote Switching Unit (RSU) to the existing switches. These digital switches, with very little blocking, have significantly improved telecommunication services in urban India. Further, these switches support RLUs/RSUs connected to them using multiple 30 channel 2.048 Mb/s CEPT (G-703) links The local loops are terminated at the RLU/RSU which has the subscriber line interface. The switching and administration services are provided at the main switch.

The RLU acts as a concentrator to connect the subscriber to the switch using one on the available ports on the 2 Mb/s links whenever a subscriber is called or makes a call. The RSU, in addition, switches calls between subscribers connected to it. Typically, 800-1000 subscribers are supported on four 2.048 Mb/s links (or 120 channels).

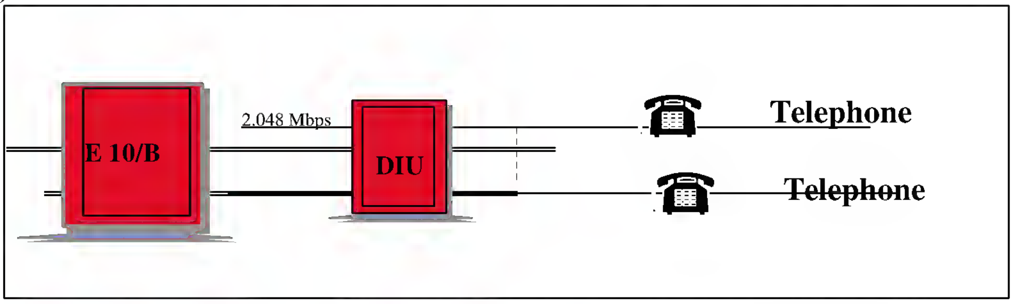


Figure 5 - An RLU used to connect subscribers to a switch via 2.048 Mb/s links

Besides the 30 voice channels, each of the 2.048 Mb/s links carry a 64 Kb/s signaling channel between the switch and the RLU. The signaling protocol used between the switch and the RLU/RSU is not standard and varies for different types of exchanges. Modern digital switches are designed to support a large number of RLUs/RSUs simultaneously. A number of subscribers are grouped into a cluster, a geographical area served by one or more base stations in which a subscriber has mobility, that is, the handset can hand over the call to any of the bases in the cluster which maintaining the integrity of the call. The cell area is not pre-defined and may vary depending on the propagation condition of the radio signals. One DECT Interface Unit (DIU) provides the control and concentration functions for all subscribers in a cluster.

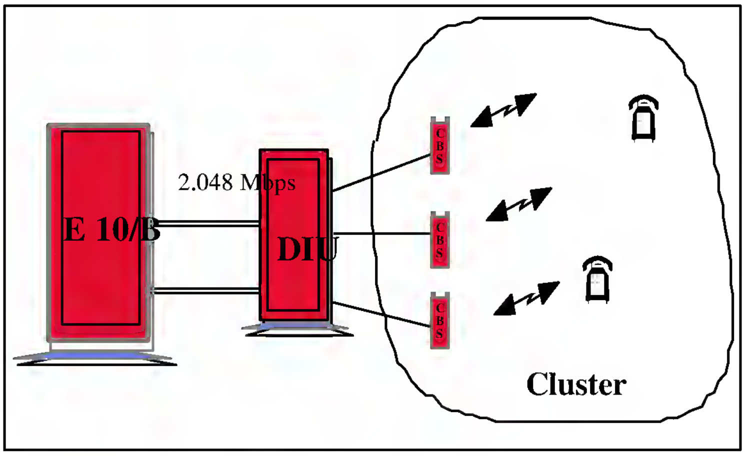


Figure 6 - A DECT WLL used to connect many hand sets via a few base stns to a DIU and then to exchange.

Each base serves one cell, each DIU serves one cluster. The link from the DIU to each base station provides full-duplex ADPCM (32 Kb/s) channels along with the required signaling. The link is provided on standard telephone wires and can use Narrow band ISDN on three pairs to achieve the required bit rate. Alternatively, 2.048 Mb/s links with drop-and insert facility can be used, serving as many as four base stations.

The base stations are small units which can be mounted on poles or on junction boxes. Each base can provide WLL to 30-80 hand set, depending on how many are office phones and how many are residential. Since 12 channels are provided by each base station, the number of hand sets supported depends on the concentration that is acceptable (the RLUs deployed today in the network employ a concentration factor of 4-8).

The base-handset link is the MC-TDMA radio link described in Section 3 and 4. The base broadcasts its signals to the subscribers located in one cell (again, defined in terms of propagation conditions). The DECT handset listens to the base station broadcasts in the vicinity and locks itself to the base from which it is currently receiving the strongest signal. Therefore, the handset or portable does not strictly belong to a cell and can move within a cluster, connecting to different base stations at different times.

4.2 DECT WLL as RLU/RSU

The DECT WLL will be designed to appear as an RLU/RSU to the switches. The interface is though the standard 2.048 Mb/s links as described above and the software on the switch side is not altered in any manner. The DECT-WLL will consist of three subsystems:

a) DECT Interface Unit (DIU).
b) DECT Base station or fixed part (BS).
c) DECT handset or portable part (HS).

WLL appears as an RLU/RSU further helps in reducing the cost. In a typical scenario, a DIU may have four G703 links to the exchange and support 20 base stations and 800-1000 subscribers. Assuming 1000 subscribers and four G703 links, we notice the following:

a) Line cards for subscribers are not required at the exchange. Instead of line cards for 1000 subscribers, only four 30-channel G703 link interfaces need to be provided at the exchange.
b) Even at the DIU, a line interface is not required for each subscriber, whereas in a conventional RLU/RSU, a line interface is needed for each subscriber.

c) The transcoding of PCM to ADPCM and vice-versa can be carried out at the DIU and needs to performed only for 120 channels.
d) The links from the DIU to base station can carry ADPCM voice instead of PCM voice, reducing the link capacity required. The base to handset communication is, of course, wireless and in ADPCM format as defined by DECT.
e) Each handset has the PCM codec and PCM-ADPCM transcoder as required by DECT.

4.3 DECT WLL Network Protocols

DECT is an all-digital network. Besides call signaling, it requires extensive data communication for control. This includes coping with and allocation of radio channels. Since radio links have a operation. With all this, DECT is akin to a packet-switched computer network. The design of DECT draws heavily on the years of technology development experience in computer networking. All signaling and control in DECT uses packet

communication. This necessitates multiple protocols layered according to the OSI standard. A fall out of this design is that DECT is well-suited as a wireless LAN also.

4.4 What is a Protocol ?

For meaningful communication to take place between two or more entities such as persons or computers, certain conventions must be agreed upon and followed by all parties. These include the communication medium , the interpretation of each symbol in the message, and the reaction of one party to each action of the other. Such a set of conventions is a protocol. Communication can take place only if all interacting parties use exactly the same protocol.

4.5 Why DECT WLL Needs Network Protocols

The different components of the DECT WLL need to communicate various types of information amongst themselves, and to work co-operatively on various tasks. These include:

Radio Channel allocation :Each handset and base can communicate on any one of 120 channels. The channel used may change from time to time due to motion of the handset etc. For fair and efficient allocation of time slots, a medium access control (MAC) protocol is used.

Each of the above tasks requires a protocol. In addition, radio is susceptible to noise which can cause errors in information being transmitted. In some cases, this may not be a serious problem, e.g., some "static" in an audio signal can usually be tolerated by the listener. In other cases, however, noise can be problematic, e.g., the dialled number changing from 235-1365 to 435-1365 by a single bit being corrupted during transmission is clearly unacceptable. Hence, the protocols for some of the above tasks must include error detection and correction measures.

4.6 DECT WLL - An Economical Solution

In addition to the wired local loop, each subscriber has to have a dedicated part of the circuit on a line interface card in the switch or RLU/RSU. It is the local loop and interface circuit required on a per-subscriber basis which form a significant part of the cost of a telephone line. The local loop is 30-40% of the overall per-line cost, and the line cards are around 50% of the cost of the switch. The DECT-WLL proposes to replace the wired line to the subscriber premises by wireless access. Cost - effectiveness as well as maintainability are primary considerations. Making the DECT-WLL appears as an RLU/RSU further helps in reducing the cost. In a typical scenario, a DIU may have four G703 links to the exchange and support 20 base stations and 800-1000 subscribers.

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The approach is not only cost-effective , but also reduces the processing at the base station as no transcoding is performed there. The base station becomes smaller and can be operated by power supplied from the DIU. Its maintenance also becomes simpler. The DIU be located at the exchange, which would have a power plant and maintenance personnel. It is possible to place the DIU away from the exchange and nearer the locality being served by providing the 2048 Mb/s links with the exchange on twisted pair.

4.7 DECT WLL Initial Installation and Growth Scenario

As described earlier, DECT caters to very high traffic density levels. Simulations performed by ETSI have shown that a traffic density of a large as 10,000 E/km2/floor be achieved in multi-storey office complexes by increasing the number of base stations. In a residential environment traffic density of 250 E/km2 can be easily achieved by mounting the base stations on poles or placing them in residential building .It is important to note that since no frequency planning is required, base station installation is unco-ordinated.

Let us take typical urban residential area and examine how DECT WLL can be installed. Let the area be 1 km x 1 Km. The base station needs to be located every 200-300 m apart .

The spacing between base stations need not be uniform and the exact location of the base station is unimportant Any handset in the area will now find more than one station at a distance less than 200-225 meters. Initially, there could be one base station for every 20 subscribers and 10 to 20 base stations. Thus 200 to 400 subscribers per sq. km could be served to start with. As the requirement for telephone service in the area grows, up to 50 subscribers can be permitted per base station corresponding to 0.1 Erlang per subscriber.

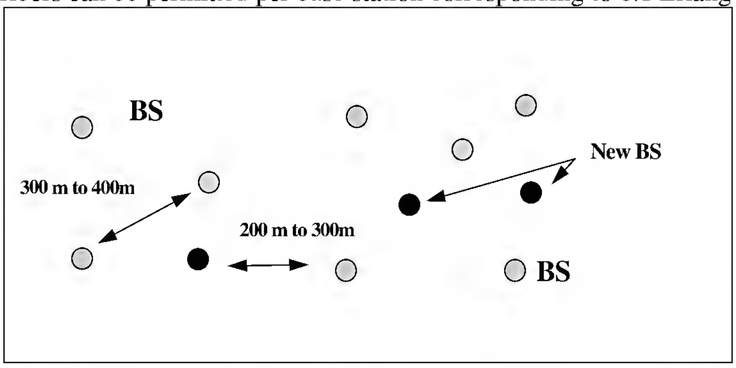


Figure 7 - DECT WLL - Initial Installation and Growth Scenario

Thus the number of subscribers can be increased to 1000 within a sq. Km without additional base stations. For areas with a number of business premises or higher residential density additional base stations can be installed to cater to higher traffic levels. Additional base stations can be installed as and when needed at any place, since base- station installation need not be co-ordinated.

The smallest DIU will have four 2.048 CEPT links to a exchange. These provide 120 channels which offers about 100 Erlang traffic (with 1% blocking) to the subscriber served by the DIU in an RLU configuration. In an RSU configuration , the capacity is higher depending on the percentage of calls between hand sets within the area served by the DIU. Since each base station can provide an average of 5 Erlang traffic to subscribers, 20 base stations can be connected to a DIU in RLU configuration, and a higher number of base station in an RSU configuration.

5. corDECT- The DECT based Wireless Local Loop

Copper wires have provided access to the telephone network for the past one hundred years. A technology has recently emerged which promises to change all this. Wireless access for mobile users is being looked at as a key component to serve subscribers in densely populated areas. Along with optical fibre, it threatens ***to break the monopoly of copper.***

5.1 Voice Coding

For the local loop, toll quality voice is required. This implies use of either 64 Kbps PCM or 32 Kbps ADPCM for voice coding. The traffic originating from a telephone should not be assumed to be less than 0.05 Erlang and could be as high as 0.15 Erlang for some lines. Yet, call blocking should be not more than 1%. The local should cater to a large subscriber density. About 1000 subscribers/sq. km would be the minimum, and in some areas with large offices, as many as 10,000 subscribers/sq. km may have to be served. It is expected that the wireless handset will have a battery which could provide sufficient back-up power, implying that it is preferable to have low transmission power. A copper-based local loop costs around from Rs 12000-18000 and therefore, the Wireless Local Loop solution should cost no more than, say, Rs. 12000 per line.

5.2 Standards

The DECT standard proposed by the European Telecommunication Standards Institute(ETSI) is a third-generation cellular system meant for providing wireless access to networks of various types, from the PSTN to LANs. It deals only with the task of defining the air interface to the user. The implementation.

5.3 Frequency band

The RF band allotted to DECT is 1800-1900 MHz. All DECT-based systems operate on the common band with no requirement for regulation. The DECT standard employs Time Division Multiple Access(TDMA). There are 10 frequencies of operation in the 20 MHz band, with a spacing of 1.728 MHz. The burst-rate is 1.152 Mbps, accommodating 24 slots. The communication is Time division multiplexing(TDD). The power transmitted by handset or base station is 250 mw during the burst, or about 10 mw average power.

5.4 Services

DECT employs 32 Kbps ADPCM. This ensures toll quality and permits all the data (Fax/modem) services available from a conventional wired connection. It is also possible to occupy a double-slot to transmit at 64 Kbps using PCM. This permits upgradation to narrow-band ISDN(actually, the double-slot permits a rate somewhat higher than 64 Kbps to allow for the D channel of (N-ISDN).

5.5 Access Technology

A very important feature that sets DECT apart from conventional TDMA systems is that all the slots in a TDMA frame need not be transmitted on the same frequency. Each of the 12 slots could be on a different frequency, though the pair of slots used for each TDD link must be on the same frequency. This variation of TDMA is called Multi-Carrier TDMA(MC-TDMA) and is the key to the high capacity achieved by DECT. The 12 slot-pairs and 10 frequencies give rise to 120 channels, as if they are independent of one another.

5.6 Dynamic Channel Selection

The DECT standard employs a completely decentralized channel allocation procedure called Dynamic Channel Selection (DCS) or Adaptive Channel Allocation (ACA). In this approach, the available set of channels are not distributed a priory among the cells. Any handset can set up a call on any of the channels., deciding on the one it will use at a given time by measuring the signal strength in that channel at its geographical location. Thus, DCS is the key to the high capacity of systems like DECT. It more than makes up for the inefficient bandwidth utilization due to other constraints and effects channel allocation based on

a) the actual traffic situation
b) the actual interference situation. It gives significant capacity gain when compared to other channel allocation schemes.

DCS Advantage

- Overcomes propagation environment
- Makes frequency planning redundant
- Cells can be overlapping
- Channels can be re-used very often

Figure 8 - Advantages of Dynamic Channel Selection

5.7 Major Subsystems of corDECT

The corDECT system has four major subsystems:

a)	DECT Interface Unit(DIU)	Performs system control and interface to PSTN
b)	Compact Base station (CBS)	Provides wireless access in an area with twelve channels per
c)	Handset(HS)	Portable telephone providing voice service to a user.
d)	Wall set(WS)	Wireless fixed terminal that is connected to any standard telephone. fax or modem.

Each corDECT unit comprises of one DIU, up to 20 compact base stations, and up to 1000 number of hand sets and wall sets, typically between 30 to 70 per CBS. A wall set can be used up to 3 Km from a base station with a line-of-sight-link, while a handset can be typically used up to 50-200 m from a base station depending on the obstructions between the base station and itself. Each base station is connected to the DIU using three 0.5 mm copper twisted cable.

The **DIU** is an ADPCM switch used as an interface between the PSTN and the base stations. All incoming and outgoing calls are routed via the DIU to the CBS. Functions such as call control, CBS powering PCM/ADPCM transcoding, call set-up and tear-down, are handled by the DIU. System operation and maintenance (O&M),and remote fault monitoring are also performed form the DIU.

DECT Interface Unit

- ***Fully redundant***
- ***ADPCM switch***
- ***PCM - ADPCM transcoding for PSTN interface***
- ***Call processing***
- ***PSTN signalling interface***
- ***Operation & Maintenance***
- ***Remote powering (120V DC) / management of CBS***
- ***Protection circuitry for accidental human contact on BS pairs***

Figure 9 - Features of the DECT Interface Unit

The Base station is a small, unobtrusive pole-mounted or wall-mounted unit. Each CBS serves one cell, providing up to 12 simultaneous speech channels. The cell radius depends on the propagation environment and antenna gain of the handset/wall set Typically, it ranges from 50-1000 meters. The CBS has two antennas for diversity.

24 cm x 16.5 cm x 9.5 cm
Weatherproof
All 12 slots - no blind slot
Internal / external antenna
Three 0.5 mm via copper pairs towards DIU
2B+D basic rate on each pair
Power fed on all 3 pairs from DIU
Works on 1/2/3 pairs (4/8/12 simultaneous calls)
Upto 3 km distance from DIU

Figure 10 - Features of the Compact Base Station

The Handset is a small, lightweight portable unit operated from re-chargeable batteries It allows the user to make calls from within the coverage area of any of the base stations connected to one DIU. The handset has intelligence to hand over seamlessly form one base station to another. The same HS can be used with different DIUs(say at home and office) by appropriate re-registration when moving from one location to another.

The Wall set is a small wall-mounted unit with an external antenna and powered from a/c mains. A battery provides backup in case of power failure. The external antenna provides gain and extends the range of a CBS in areas where CBS density is low. The wall set provides a standard RJ-11 telephone socket so that any telephone, fax machine, modem or even a pay phone can be connected to it.

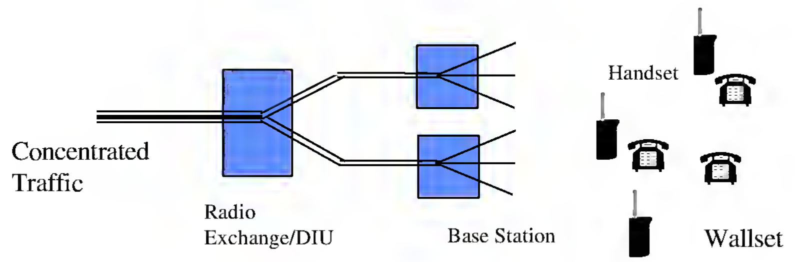
20 cm x 20 cm x 4 cm
230V AC powered
Battery backup (upto 24 hours idle-time)
Blind - slot implementation
Standard 2W RJ-11 interface
16 kHz metering pulses
External / integral antenna

Figure 11 - Features of The Wallset

5.8 PSTN Interface

The DIU can be interfaced to PSTN in three different configurations. In the first configuration, the DIU is connected to a PSTN using E1 lines with R2-MF protocols and acts as an independent exchange. In the second configuration, the interface between the DIU and the PSTN is called Incoming Trunk Outgoing Subscriber(ITOS) interface. Thirdly the DIU may act as a PBX connected to a parent Exchange via two wire subscriber lines.

PSTN Interface



- **Connect DIU through trunk lines to PSTNs**
  - DIU is an independent exchange
- **Connect DIU as RSU to an Exchange with V5.2**
- **DIU with ITOS interface to an exchange (DID PBX)**

Figure 12 - PSTN Interfacing possibilities

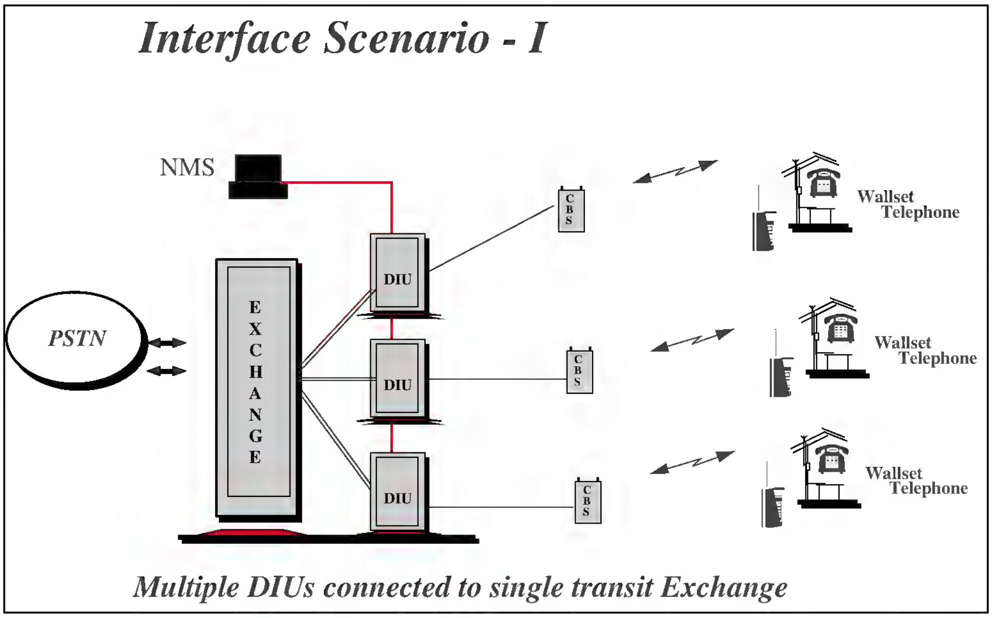


Figure 13 - Interface Scenario- 1

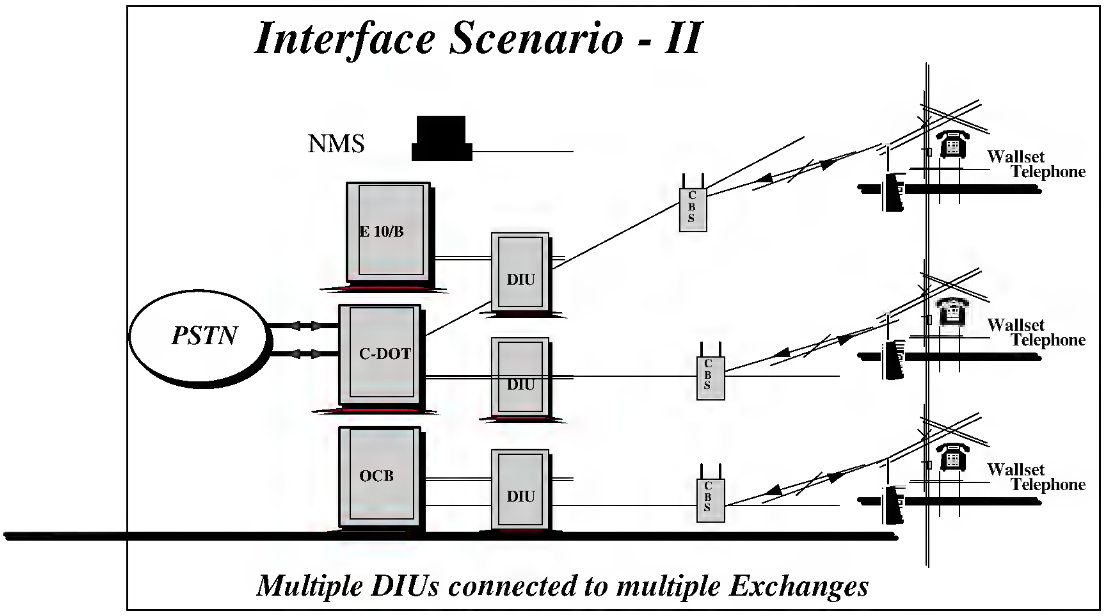


Figure 14 - Interface Scenario II

5.9 A Typical Configuration of The corDECT System

A typical corDECT system configuration is shown in the figure below. The DIU can cater for 300, 600 or 1000 lines. A corDECT system can support up to 1000 subscribers. Each base station can ???

Typical Configuration

- **1 DIU, 20 Base stations, 1000 Subscribers**
- **DIU interconnection to PSTN :**

  Upto 6 E1 (2.048Mbps) lines
- **BS connection to DIU :**

  3 Pairs of tp 0.5 mm copper

Supports 5 Erlang at 0.5% blocking
At 0.07 E/line => 70 Subscribers
At 0.15 E/line => 35 Subscribers

Figure 15 - Typical Configuration of a corDECT System

6. The corDECT Deployment Scenarios

Being an open standard, DECT defines only the air interface between the base station and the customer terminal unit. The interface from the Base Station controller to the PSTN is left to the operator to choose, depending upon existing infrastructure, terrain, number of subscribers, and economic and country specific regulatory conditions. It can be any of the standard backbone technologies—coaxial, fiber or digital microwave. Thus, there is a great extent of flexibility in deployment irrespective of the subscriber base—dense urban / suburban, business districts, rural or isolated pockets like factories, resorts etc., which may be located away from populated areas and the PSTN switch.

The corDECT Wireless Local Loop system is a truly scaleable system which is Ideal for a green field network and also to expand existing telecommunication network. corDECT with its central NMS system will be able to control a vast service area with out locating service personnel in all corDECT installations.

corDECT systems can be deployed in several economical ways. The service providers and operators are recommended to use the most appropriate solution to maximise the coverage and revenue.

corDECT solution works on existing or new PSTN networks and assumes there is enough switching capacity and bandwidth available or going to be made available as the **demand grows in the local loop.**

6.1 A Few Possible Scenarios for corDECT Deployment

a) DIU at the exchange and CBS at street level.
b) DIU and cluster of CBS at exchange
c) DIU in a remote location with CBS cluster.
d) Multiple DIUs on a fibre backbone.
e) CBS clusters with digital microwave link.
f) CBS clusters with HDSL or fibre links.

6.2 DIU at the Exchange and CBS at Street Level

This is simple configuration which is ideal in places where existing wire plant is unable to cover vast areas and new subscribers, also it is difficult to expand the network in the urban / rural areas. In such situations existing wire plant can be released for wireless local loop and a quick expansion can be undertaken with out worrying about the last mile problem.

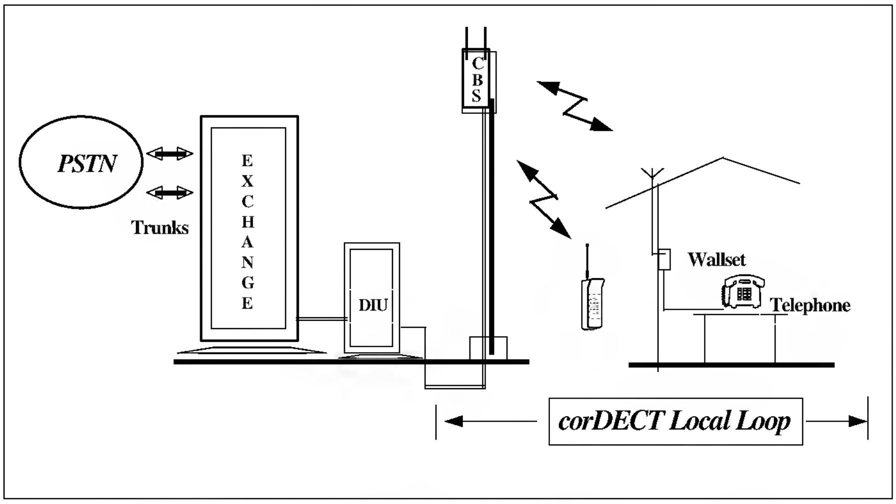


Figure 16 - DIU at Exchange and CBS Cluster at street level

This will enhance the utilisation of the switching capacity of the network and reduces the breakdowns and maintenance problems of the copper local loop. This is a very economical solution.

The DIU (DECT interface unit) is installed in the Exchange and street level base stations will serve the neighbourhood Power feed to the Base stations are from the DIU hence Bases stations are virtually maintenance free at street level and do not fail when there is no commercial power . Each base station can handle 12 simultaneous calls and serve 50-75 subscribers depending on the load and the grade of service. One DIU itself can provide service for 1000 subscribers. As the network expands more DIUs and base stations can be added on need basis. This way investment is proportional to the revenue generation or demand. The base station installation is purely on demand basis and no frequency planning required.

Subscriber premises equipment can be a fixed Wallset or Handset.

Customer can register handsets in 4 different locations in a service area. This way same number can be used to make and receive calls from office home and market place or Airports. The one bill will be generated for the subscriber for all these calls at normal POTS tariff. Hence more number of calls are generated per subscriber. This will enhance the revenue to the operator and leads to better utilisation of network.

6.3 DIU and Cluster of CBS at Exchange

In this scenario the Local Loop is totally wireless. This is Ideal in residential areas and suburbs. Base station cluster is a tall structure or tower which can house multiple Base stations with directional Antennae. This will sectorise the coverage and adequate overlapping of sectors ensure uniform coverage in a very large area.

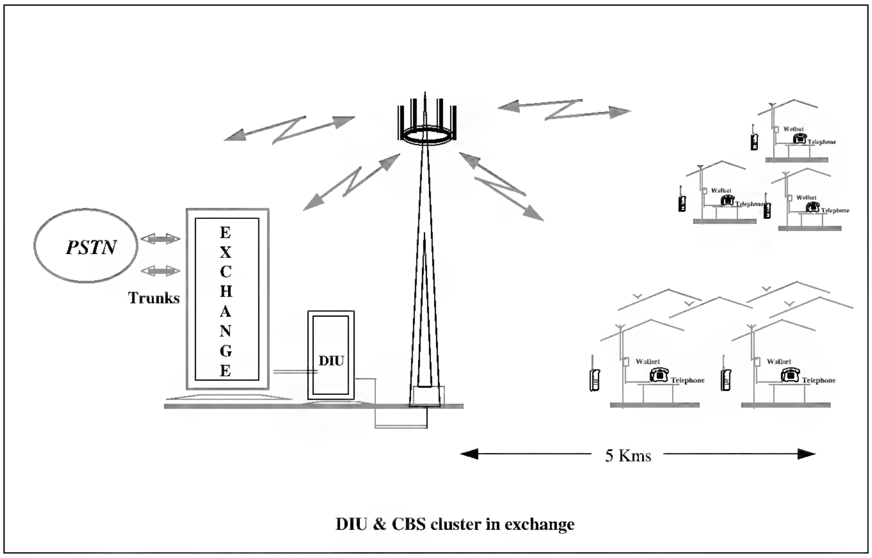


Figure 17 - :DIU and CBS Cluster Collocated

It can be as large as 30 Sq. Kms. (Radius of 3 Kms) or even more depending on the terrain and application. The base station clusters can be added as the demand grows and ***no frequency panning required.*** In this type of solution a topographic planning is required to get maximum coverage from one BS cluster.

6.4 DIU in a Remote Location with CBS Cluster

In this solution the Exchange can be located far away from the service area and Co-axial links can be provided upto city centres where DIUs and Base stations can be co located to provide service to concentration of subscribers.

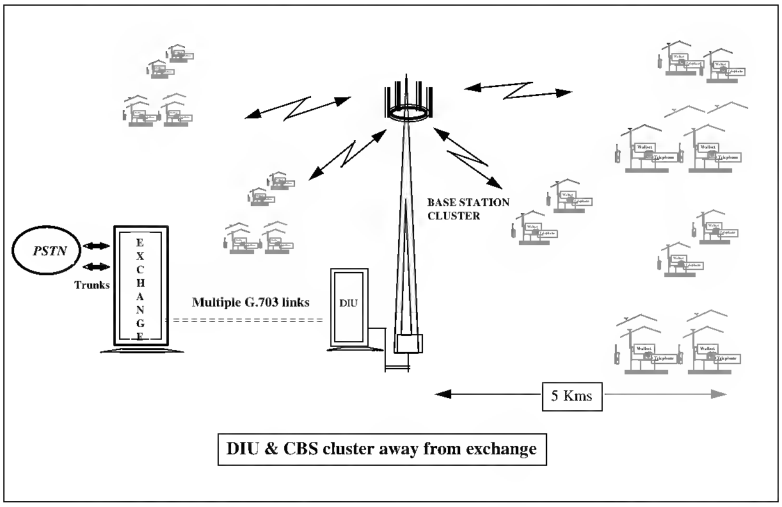


Figure 18 - DIU and CBS Cluster collocated but remote from Exchange

This is a Ideal solution for new installations where real-estate in side cities are be prohibitively expensive to install large capacity switches. However the DIU locations can be franchised small operators by which investment can be minimised. This way a new operator can enter city centre with very small investment in infrastructure. Multiple DIUs can be installed in same location or in different locations to provide maximum coverage.

6.5 Multiple DIUs on a Fibre Backbone

The Wireless Local Loop is implemented in this situation by using a large switching capacity provided by the central exchange. The fibre optic ring can be built to drop channels at Every DIU installation this way the solution totally eliminates the use of copper. This is a very elegant solution. This requires additional multiplexers at DIU locations which can drop or insert channels on the back bone fibre network.

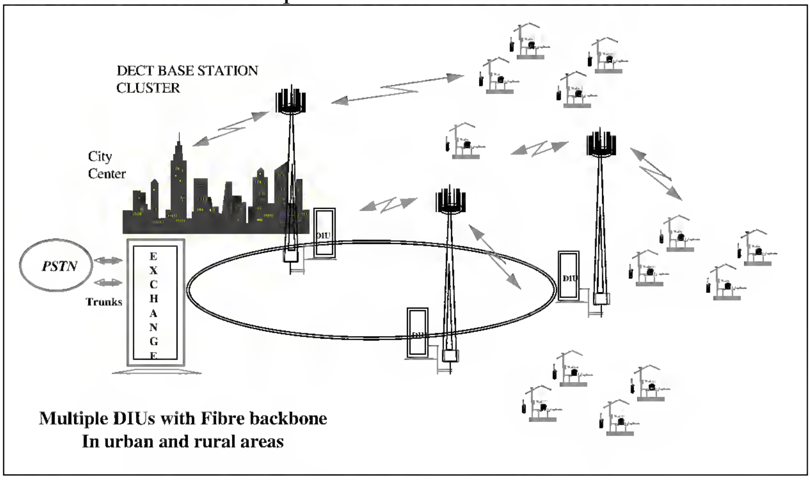


Figure 19 - Multiple DIUs with Fibre Backbone

6.6 CBS Clusters with Digital Microwave Links

The back bone network of the metropolis can be built around a Scaleable point to multi-point Digital Microwave network. These microwave links are terminated at DIUs which are wide spread. For the DECT WLL applications 3 GHz, 10 GHz, and 26 GHz can be used depending on the traffic and the distance requirement. At lower frequencies the distance coverage can be as long as 20 kms line of sight and higher frequencies the distance comes down to 5 kms but reuse of same frequency possible. These networks are very reliable and properly planned totally eliminates the need for copper or fibre.

In this solution the additional cost of PMP microwave system is still attractive considering the advantages it has. This solution needs clearance from the regulator for the additional frequency utilisation.

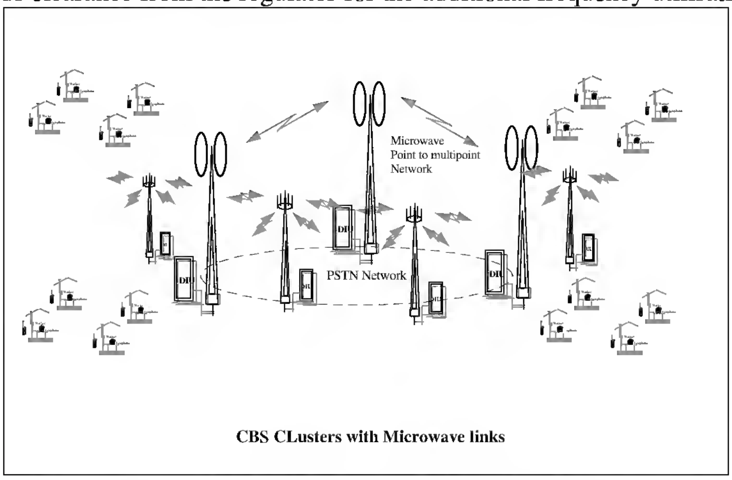


Figure 20 - CBS Clusters with Microwave links

6.7 CBS Clusters with HDSL or Fibre links

In this solution the street level base station is served by a single pair of copper wire which can deliver 720 Kbps of bandwidth using High density subscriber link. This is possible in using the new HDSL technology which can enhance the capacity of existing copper pair. Hence effectively one copper pair can serve 50 - 75 subscribers and handle 12 simultaneous ADPCM calls. HDSL network is normally a star network.
Using fibre for base stations is possible when cluster of base stations have to be deployed in multiple places. In this situation multiple DIUs are housed in the exchange building and with help of multiplexers (Bandwidth

resource managers) the channels are aggregated at the exchange and selectively dropped at the Base station clusters with the help of a small mux. This even though calls for additional investment, is still a clean solution and fully satisfies the regulatory conditions where copper usage is prohibited in the local loop.

7. Validation Issues - ETSI Certification

The best part of the DECT is the standardisation work which has been done by ETSI and guidelines for testing and certification. This makes DECT a open standard and also to ensure compatibility among manufacturers of DECT product. The following are the available standards and guidelines for ETSI certification. These tests can be conducted in any of the approved test houses in Europe and the equipment gets CE approval which can be sold installed on any public network in Europe. In few countries the certification has to be revalidated by the local authorities. Many other WLL technologies may be proprietary and many not be able to certify by a independent body or test house. This is a important factor in selecting a technology for deployment in a public network.

1. The Common Technical Regulations (CTRs) and the Technical Basis for Regulations (TBRs) are the basic yardstick for Type approvals by independent Type approval houses in Europe for DECT products. The Type approval by any one agency is good enough to use the equipment anywhere in Europe.
2. The following are the guidelines for type approval which are available now:

CTR 6	'Basic rate"	Radio
CTR 1	'Speech'	Audio
CTR 1	Public Access Profile PAP	

This is being replaced by Generic access protocol. The TBR for this is going to be CIR22.

3. The new TBRs which are going to come to effect in near future are:
   TBR for DECT/GSM interworking - during 1996
   TBR for DECT/ISDN interworking - during 1996
   TBR for DECT/GSM dual mode is planned for 1996.

8. Technology Alternatives—Often Asked Questions By Operators And Service Providers

As operators and service providers around the world begin to deploy digital wireless systems, they are often confronted with the difficult decision making necessary before the choice of technology can be made. Till recently most digital systems have used one of three TDMA standards. Now new CDMA based standards are emerging challenging TDMA very strongly. The debate on the relative merits and demerits has been raging for years but till now there are no real world large deployments CDMA based systems anywhere to be able to draw firm conclusions. However much of the debate has been on the relative merits and demerits of the two technologies/ standards from the point of view of **mobile wireless communications** and **not as Wireless Local Loop Systems.** There has also been considerable debate of **TDMA** Vs **CDMA** and **Micro** Vs **Macro** systems in the wireless local loop, but the fact remains that as of today no macrocellular system has been deployed in the wireless local loop. Yet you will find companies trying to sell systems, technologies and solutions to third world countries which were primarily design optimised for the mobile wireless communications and not for the wireless local loop.

Hence it is essential for marketing personnel to be aware of the often asked questions by operators and have ready answers. We have attempted to answer these questions in the form of a comparison table below.

Network access technology is the key criterion for effective provision of service to the customer. This access can be provided with two distinct technologies. The critical issue however is while providing a wireless local loop or replacing the wired local loop with wireless it is necessary that the quality and range of services that are provided over the wired loop should be maintained at the same level. Also the technology should be able to support services that are planned for the future- that is it should be “future proof” There is no technology that is optimal for all deployment scenarios and the choice will depend on numerous parameters which are listed in the table below with an indication of the relative merits and demerits of the two technologies.

No	Parameter	Microcellular	Macrocellular	Remarks
1	Ease of deployment	More complex as partly wired solution.	Less complex as fully radio solution.	In the case of microcellular systems also immediate fully radio solution. Available to limited number of subscribers in line of sight range of base stations. Collocated with DIU.
2	Speed of deployment	More time for deployment due to requirement of cable	Quick installation for limited no. of customers	
3	Expansion of customer base	Easy as base stns. Can be added as demand dictates	More complex as greater level of co-ordination required.	
4	Flexibility of deployment	Traffic handling per base stn. Flexible to accommodate needs of residential and commercial areas.	Less flexible due to a single base station catering to all categories of subscribers and areas with varying traffic densities.	
5	Design optimization	Optimized for WLL applications.	Optimized for mobile applications	

No	Parameter	Microcellular	Macrocellular	Remarks
6	Suitability for dense urban applications	Design optimized for dense urban applications	Design optimized for comparatively thin route applications.	For spectrum availability of 20 mhz, spectrum per channel of 60 khz, 0.1 Erlang traffic and ideal frequency reuse subscriber density/ sq. km : Micro[250 m cell radius]: 17000 without sectorisation and 51000 with three sectors Macro[10 km cell radius]: 11 without sectors and 32 with three sectors *Please see table at the end.*
7	Speech compression techniques	32 kbps adpcm, 64 kbps pcm and 144 kbps ISDN possible	Uses speech specific compression algorithms as low as 8 kbps	Compression algorithms that take the bit rate down to 8 kbps or lower by exploiting speech specific properties cannot handle modem or fax signals which are not speech like.
8	Capability for g3 fax and data	Yes	No	
9	Maintenance	Easy	Much more complex	
10	Redundancy	Built in at low cost in the basic design and by overlapping cell coverage by base stns.	Very complex safeguard systems required since one transmitter serving many customers.	

No	Parameter	Microcellular	Macrocellular	Remarks
11	Frequency planning	Not required	Required	Micro: allows uncoordinated installation of base stations as per current subscriber density and expansion in consonance with growth of subscriber demand.
12	Power planning	Not required	Power planning is complex and sophisticated power control algorithm required.	
13	Blocking/non blocking and resultant grade of service	On fully loaded system add. Channels automatically blocked but no degradation of grade of service	Totally non blocking at the cost of BER degradation	
14	Frequency reuse	Reuse factor of nearly 1	Typically reuse of 1 in 4 cells but nearly 1 achievable under certain circumstances.	
15	Sensitivity at cell borders	Intercell seamless hand off	Maintains connection with earlier cell ,uses "soft hand off" uses more than one demodulator and hence pushes up cost	
16	Support of hierarchical cell structure	Supports	Does not support	

No	Parameter	Microcellular	Macrocellular	Remarks
17	Egg phenomenon	No due to micro and macro cells overlapping on one another	Yes	Egg phenomenon : Coverage is not perfectly circular around the omni antenna but is oval shaped. Hence different coverage ranges in different directions.
18	Price drivers- handset/wall set	Low cost	Very high cost due to greater complexity of handset/wall set	
19	Base station and base station Controller costs.	Small fraction of the total per line cost.	Significant portion of the total per line cost	

Subscriber Density

Assume:

Spectrum available	**:**	**20 MHz**
Traffic	**:**	**0.1 Erlang**
Spectrum per Channel	**:**	**60 KHz (30 KHz each way)**
Assuming reuse every cell	**:**	**Ideal reuse**

Number of subcribers/Sq. Km

Cell Radius	Non-Sectorised	3-Sectors
0.25 Km	17,000	51,000
0.5 Km	4,240	12,700
1 Km	1,060	3,180
2 Km	270	800
3 Km	120	350
5 Km	43	129
10 Km	11	32

Figure 21 - Microcellular Vs Macrocellular systems.- a comparison

9. Regulatory Issues

The time has come for the Telecommunication regulators of the world to take a serious note of what is happening in the DECT world and how they can use DECT in their countries through operators and private users. As on today there is a divergent view for DECT application in Radio local loop in many countries; however many regulators today agree to the fact that DECT is very good standard which should be utilized.

9.1 Regulators view point

1. DECT needs more frequency band (current band is 1880-1900 Mhz) to support ISDN services.. It appears that this request is gaining momentum in the DECT world. Another 30-40 Mhz of frequency band may be required. This may be of concern to many regulators. But for WLL applications the present 20 Mhz of band is sufficient to achieve very high telephone densities.
2. In "Hot spots" like Airports, Downtown areas, Railway Stations, etc., the DECT frequency may interfere with other operators equipment and also with private PBX installation in that area. However this interference is not significant compared to other technologies.
3. Ten carrier frequencies should be reserved for private DECT applications. This viewpoint of a few regulators is to distinguish between office cordless applications and WLL is view point of few regulators to distinguish between office cordless application with WLL. This is not the view of ETSI.
4. These should be a strategy to interwork with public networks of different operators by synchronizing the networks. This is a very important point in many countries where network synchronization is a must to connect to public network.
5. DECT has to provide the same level of service as wired connections, such as voice quality, Data speeds and ISDN services along with guaranteed up time.
6. Interworking standards to be developed. Regulators are accepting DECT/GSM services by the operators.

10. Conclusions

Countries with underdeveloped telecommunication infrastructures have realized that modern, reliable and efficient telecommunication facilities are essential for spurring economic growth, and ensuring better living standards and quality of life for their population. These countries need to quickly increase their telephone penetration in a cost effective manner. Importantly, this must also cater for pent-up demand, which may be unpredictable.

The critical path will be the local loop if they choose to go with traditional wire-line systems. Hence, to achieve quick and affordable increased telephone penetration, the wireless local loop is the answer. The choice of technology for the local loop would be dictated by many factors, but it would be to their advantage if they adopt an open standard which brings many manufacturers and products into the market. DECT is the standard that we recommend to achieve this objective. Not only does it meet all the most important requirements of a wireless local loop anywhere in the world , but due to its inherent features can cater to unpredictably growing demand without idle investment, as is the case of wireline systems. This one critical characteristic makes it the ideal choice for countries with an underdeveloped telecommunication infrastructure. The choice also makes sense because many countries outside North America have chosen GSM as the standard for cellular mobile services. GSM originates from the same stables as DECT and a common handset is planned for the two systems through the General Access profile.

DECT is scaleable and capable of being deployed innovatively to cater for dense urban and suburban business and residential districts, as well as less populated areas like rural areas or isolated pockets of demand like factories, resorts etc.

In most of the developed world the idea of paying $ 500 for getting plain old telephone service (POTS) may sound outrageous. however the large numbers of “telephone-starved” people in these countries, would be willing to pay a premium for a telephone connection on demand.

It is precisely this pent up demand, that provides both the operators and the consumers, the opportunities for innovative financing options.

The corDECT Wireless Local Loop solution has been designed and developed with these issues in mind. To summarise the corDECT Wireless Local Loop has the following key attributes that a WLL solution should have:

- Based on open standards
- Reaches a large number of people
- In the shortest possible time
- At affordable prices
- Can grow and expand in consonance with demand without idle investments
- Future proof.

The salient features of the corDECT Wireless Local Loop system are:

a) A state of the art WLL solution fully compliant with DECT standards.
b) Quickly and easily deployed.
c) Easily expanded in consonance with growth in demand over the whole or pockets of the service area
d) Viable and cost effective.
e) Most suited for dense urban and suburban business and residential area
f) Adaptable for low density rural and other districts.
g) The design is capable of country adaptation. (Adaptation already done for India and China)
h) The technology partners have the reference design and so production will be easy.
i) Chipsets designed can be used for corDECT applications like cordless PBX, telepoint, wireless LAN, wireless ISDN terminal and residential cordless.

11. Appendix A - KEY DECT Physical Layer Specifications

1.	RF channel center frequencies	1897.344 -1.728n, n=0,1-----9
2.	Accuracy of center frequencies	+ / - 50 Khz
3.	TDMA time frame	10 ms.
4.	Transmission bit rate	1.152 Mbps.
5.	TDMA slot length	480 bits, with 32 bits for synchronisation , 64 bits for signalling and 324 bits for voice and CRC.
6.	Accuracy of bit clock	+ / - 25 ppm at wallset/handset. = / - 10 ppm at base station.
7.	Modulation	Gaussian frequency shift keying.
8.	Frequencies deviation	+ 288 Khz (nominal) for all- one bit pattern. - 288 Khz (nominal) for all- zero bit pattern.
9.	Transmit power	+24 dBm nominal.
10.	Spurious emission	Less than -8dBm in adjacent channels. Less than -30 dBm, two channels away on either side. Less than -47 dBm in all other channels.
11.	Sensitivity	At -73 dBm, bit error rate (BER) less than 10E-5. At - 83 dBm bit error rate (BER) less than 10E-3.
12.	Interference performance	At -73 dBm , with a co-channel interferer at 83dBm, or with an adjacent channel uinterferer at 58 dBm , or an interferer 2 channels away or either side at -39 dBm, or an interferer on any other channel at -33 dBm, BER less than 10E-3.

12. Appendix B - System Capabilities

12.1 Traffic Handling

BHCA	20,000
Maximum traffic per Base Station	5 Erlang at 0.5% blocking, supports typically 33 subscribers at 0.15E or 50 subscribers at 0.07E.

12.2 Voice and Data

Instruments supported	Standard two wire telephone or payphone. Modems upto 4800 bits/sec G3 FAX
Number of tones	11
List of tones	Dial tone, special dial tone , indication tone, call waiting tone, busy tone, unobtainable tone back tone, congestion tone, intrusion tone.
Number of three party conference calls	8
Number of announcements	8 (Two 6 sec. Segments played alternately for each announcement.

13. Appendix C - General Features

1. **System configuration set up:** Addition, deletion and change of compact base station or E1 ports.
2. **Security:** Pass word(upto 7 characters) for system administrator.
3. **Mobility management** related data base-subscription, location registration, authentication, termination of access rights and class of service.
4. **Billing**: Data provided for off-line billing. The data includes cumulative local call units, cumulative STD call units, detailed billing of STD calls, local calls or both, on demand, calling party number, called party number, duration of call, time of origin, number of units, type of call (local, STD, special services.)
5. **System health monitoring:** PC based user friendly console display of health of all DIU cards / Base stations.
6. **Remote OMC**: OMC operation can be carried out remotely using a modem connected to OMC PC at DIU.
7. **Traffic Analysis:** Number of call attempts, successful call attempts on each base station and on junctions.

14. Appendix D - Supplementary Services

1. **Automatic alarm call service**
   Gives an alarm by ringing a telephone at registered time.
2. **Call completion supplementary services:**
   Absent subscriber service: Diversion of call to operator or to an announcement
   Automatic call back: Subscriber to be connected to the busy called number as soon as the called number is free.
   Do not disturb: Incoming calls diverted to an announcement.
3. **Call offering supplementary services:**
   Call diversion on busy / no reply / unconditional: Incoming calls diverted to another subscriber number in the same DIU when the subscriber phone is busy or there is no reply or unconditional.
4. **Call restriction supplementary service:**
   Incoming call only: Subscriber can only receive calls.
5. **Outgoing call only: Subscriber can only make calls.**
   Outgoing call- subscriber controlled call restriction: Dynamic STD / ISD barring.
   Outgoing call-administrator controlled call restriction: Barring of international calls, STD calls, Any calls outside DIU and barring of some special services.
   Incoming call- administrator controlled call restriction: Barring of incoming calls from outside DIU.
6. **Charging and charge debiting supplementary services:**
   Printed record of duration and charge of calls : Detailed STD / local call billing for subscribers on demand.
   Subscribers call charge meter: 16 kHz pulse provided by wall set for external charge meter.
7. **Multi party supplementary services:**
   Three party conference calling: Between a wireless subscriber and two others (wired or wireless).
8. **Rapid call set up supplementary services:**
   Abbreviated dialling: Calling a number with abbreviated code.
   Fixed destination call on time out: On going off hook the subscriber is connected to a fixed destination if no number is dialled within a pre- defined time:

15. Appendix E - Other Services

1. **Pay phone services**
   Allows installation of CCB pay phone (battery reversal only) or CCM pay phone (battery reversal with 16 Khz pulses.)
2. **Malicious call identification**
   Will record the calling number / junction number of the call ; will not allow calling party to disconnect.
3. **Ring back facility**
   Subscriber indicated service to check ringing of telephone.
4. **Operator trunk offer**
   Allows an operator on any exchange to cut into a call already set up.
5. **Temporary out of service subscriber**
   Announcement for incoming calls ; outgoing calls barred.
6. **Announcement circuits**
   Allows announcement of route congestion , change of exchange code, entitlement of service and any special service.
7. **Hunting for a group of subscribers**
   Allows incoming calls to land up on any one of the free subscribers in a group.

16. Glossary of Abbreviations

ADPCM	Adaptive Delta Pulse Code Modulation
BS	Base Station
CBS	Compact Base Station
CDMA	Code Division Multiple Access
CTR	Common Technical Regulations
DCS	Dynamic Channel Selection
DECT	Digital Enhanced Cordless Telecommunications
DIU	DECT Interface Unit
ETSI	European Telecommunication Standards Institute
FCA	Fixed Channel Allocation
FDMA	Frequency Division Multiple Access
GSM	General Service Mobile
HDSL	High Density Subscriber Loop
ISDN	Integrated Services Data Network
ITOS	Incoming Trunk Outgoing Subscriber
K	Kilo(As In 10k Lines = 10 Kilo Lines)
Kb/s	Kilobits per Second
KHz	Kilohertz
Km	Kilometers
L	Subscriber Lines
LAN	Local Area Network
MAC	Medium Access Protocol
Mb/s	Megabits per Second
MC-TDMA	Multi-Carrier Time Division Multiple Access
MHz	Megahertz
NMS	Network Management System
OMC	Operations and Maintenance Centre
PABX	Private Automatic Branch Exchange
PBX	Private Branch Exchange
PCM	Pulse Code Modulation
PSTN	Public Switched Telephone Network

RLU	Remote Line Unit
Rs	Rupees (Indian)
RSU	Remote Service Unit
SMUX	Subscriber Multiplexer
TBR	Technical Basis for Regulations
TDMA	Time Division Multiple Access
W	Watt
WLL	Wireless Local Loop
W	Wall Set